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(19) JAPANESE PATENT OFFICE

PATENT ABSTRACTS OF JAPAN

(11) Publication number: **2001128956 A**

(43) Date of publication of application: **15.05.01**

(51) Int. Cl **A61B 5/055**
G01R 33/34
G01R 33/36

(21) Application number: **2000309573**

(22) Date of filing: **28.02.91**

(30) Priority: **28.02.90 JP 02047814**

(62) Division of application: **03059513**

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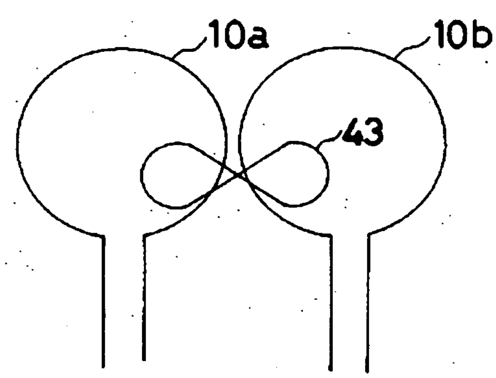
(54) **MAGNETIC RESONANCE IMAGE DEVICE**

(57) Abstract:

PROBLEM TO BE SOLVED: To provide a magnetic resonance image device capable of effectively decoupling surface coils when detecting a magnetic resonance signal from a subject through the plural surface coils to perform imaging.

SOLUTION: In this magnetic resonance image device for detecting a magnetic resonance signal through a uniform coil within the same time for detecting magnetic resonance signals through plural surface coils 10a, 10b, and these magnetic resonance signals obtained through the multi-surface coils and the uniform coil are subjected to imaging processing including Fourier transformation to generate image, a coil 43 shaped like a figure 8 is superposed on the coils 10a, 10b to prevent mutual connection between the adjacent surface coils 10a, 10b.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to magnetic-resonance-imaging equipment, and relates to the magnetic-resonance-imaging equipment which acquires a high S/N picture using a uniform coil and a Sir face coil especially.
[0002]
[Description of the Prior Art] It is thought that it is mostly completed though imaging time takes several minutes about magnetic-resonance-imaging equipment and imaging of 1H. The practically almost satisfactory grade is provided with the good picture in the image pck-up of the part also clinically accompanied by quiescence or late movement.
[0003] However, the demand of imaging ** of nuclear species other than high-speed imaging [which enables the image pck-up of the early parts (heart etc.) of movement] (about conversion-to-signals time -50ms), and 1H, such as 31P, 19F, 13C, and 23N, is large in recent years. Improvement in S/N serves as a big technical problem technically in these cases. For example, imaging time is short, there is degradation of S/N by the bird clapper, and, as for high-speed imaging ********, in-the-living-body abundance about 31P The shortage of S/N by ten to about [which is 1H] 4, and being a minute amount very much is mentioned.
[0004] In order to improve S/N, using a Sir face coil for reception of a magnetic-resonance signal conventionally is performed. Although a Sir face coil is stuck to the interested part of an analyte, and is installed and the signal of the adhesion part circumference can be detected by high S/N, there is a fault that only the picture of the adhesion part circumference is acquired, and the predetermined cross section of an analyte cannot be imaged by high S/N over the whole region.
[0005] on the other hand -- the request field of an analyte -- setting -- the inside of a field perpendicular to a static magnetic field -- abbreviation -- if the so-called uniform coils (for example, a saddle type coil, Slotted tube resonator, a birdcage type coil, etc.) which generate a uniform RF magnetic field are used for reception of a magnetic-resonance signal, the picture of the whole request cross section of an analyte will be acquired If this uniform coil is used by the quadrature receiving method, it will be S/N at the whole picture 21/2 It can be made to double-improve. However, S/N of the magnetic-resonance signal acquired using a uniform coil cannot obtain S/N as the adhesion part circumference at the time of using a Sir face coil.
[0006] In order to solve the above problems, on the U.S. JP,4,825,162,B specifications Two or more Sir face coils are arranged to the field of the request which should image an analyte. The magnetic-resonance signal from an analyte is detected through the Sir face coil of these plurality, respectively. After performing imaging processing respectively about the detected magnetic-resonance signal and generating the image data of two or more sequences, The pixel data (a single complex signal or single dimension complex signal = spectrum signal) corresponding to the same spatial position The technology of acquiring a high S/N picture is indicated by making the data of each pixel and compounding one picture of a request field by multiplying by it and adding the weight function beforehand decided based on the distribution of the RF magnetic field which each Sir face coil generates.
[0007] Even if it passes the high frequency current of predetermined frequency in one Sir face coil so that a Sir face coil may not interfere mutually regularly namely, in order to observe a magnetic-resonance signal simultaneously with two or more Sir face coils to within a time [which is taken to acquire the picture of one sheet], it is necessary by such method, for other Sir face coils to prevent the cross coupling of a coil so that the high frequency current may not flow.
[0008] Moreover, although it may come to compare S/N of the magnetic-resonance signal acquired when two or more Sir face coils have been arranged so that the area of interest of an analyte may be covered when a uniform coil is used by the quadrature receiving method near the coil, S/N in the furthest point also from the center, i.e., every Sir face coil, of an analyte being equivalent to the case a uniform coil being used by the quadrature receiving method, or the theoretical corroboration of exceeding it is not obtained yet.
[0009]

[Problem(s) to be Solved by the Invention] As mentioned above, magnetic-resonance signals are simultaneously collected using two or more Sir face coils, and it becomes a technical problem how the decoupling between each Sir face coil is performed simply and certainly in the Prior art which acquires a high S/N picture by carrying out weighting addition of the obtained image data.
[0010] Moreover, although imaging will be possible in high S/N on the outskirts of an adhesion part of an analyte if a Sir face coil is used, S/N falls rapidly as it separates from an adhesion part.
[0011] On the other hand, if the uniform coil using the quadrature receiving method is used, although the picture of the whole request cross section will be acquired, it is less than S/N of the adhesion part circumference at the time of using a Sir face coil.
[0012] The purpose of this invention is to offer the magnetic-resonance-imaging equipment which can perform the decoupling between each Sir face coil effectively, when imaging by detecting the magnetic-resonance signal from an analyte through two or more Sir face coils.
[0013] Other purposes of this invention are to offer the magnetic-resonance-imaging equipment which can attain S/N equivalent to realizing when high S/N equivalent to the case where a Sir face coil is used near the front face of an analyte is obtained using the decoupling technology between such Sir face coils and the deep part of an analyte also applies a quadrature receiving method to a uniform coil at least.
[0014]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the magnetic-resonance-imaging equipment concerning this invention A means to impress a static magnetic field to an analyte, and a signal-detection means to detect the magnetic-resonance signal from an analyte through these Sir face coils including two or more Sir face coils arranged to the request field of an analyte, A joint prevention means to prevent the cross coupling between the coils which adjoined at least among two or more aforementioned Sir face coils is provided, and the aforementioned joint prevention means is characterized by being arranged in piles at the coil in which the figure of 8 coil or the loop-like coil carried out [aforementioned] contiguity.
[0015] While other magnetic-resonance-imaging equipments concerning this invention impress a static magnetic field to an analyte The uniform coil which serves as a means to impress a gradient magnetic field pulse from the inductance element and capacitance element for generating a RF magnetic field in a field perpendicular to the aforementioned static magnetic field in the request field which should image an analyte, Two or more Sir face coils arranged in the space which approached the aforementioned analyte and was surrounded with the aforementioned inductance element and capacitance element of the aforementioned uniform coil, A signal-detection means to detect the magnetic-resonance signal from an analyte respectively through the aforementioned uniform coil and two or more Sir face coils, The 1st joint prevention means which prevents the cross coupling of the aforementioned uniform coil and the aforementioned Sir face coil, The 2nd joint prevention means which prevents the cross coupling between the coils which adjoined at least among two or more aforementioned Sir face coils is provided, and the joint prevention means of the above 2nd is characterized by being arranged in piles at the coil in which the figure of 8 coil or the loop-like coil carried out [aforementioned] contiguity.
[0016] Thus, in this invention, the cross coupling between the contiguity coils of two or more Sir face coils can be prevented simply and certainly by arranging a figure of 8 coil or a loop-like coil in piles in the coil with which two or more Sir face coils adjoined.
[0017] Moreover, two or more Sir face coils in the space surrounded with the inductance element and capacitance element which constitute a uniform coil By arranging, where it prevented cross coupling with a uniform coil and combination between adjoining coils is prevented as mentioned above, and detecting a magnetic-resonance signal using both [these] coils S/N equivalent to the uniform coil with which high S/N equivalent to the time of using a Sir face coil near the front face of an analyte was attained, and the deep part of an analyte also applied the quadrature receiving method at least realizing is obtained.
[0018]
[Embodiments of the Invention] Hereafter, the example of this invention is explained with reference to a drawing. Drawing 1 is the block diagram showing the composition of the magnetic-resonance-imaging equipment concerning one example of this invention.

[0019] In drawing 1 , the static-magnetic-field magnet 1 is excited by the power supply 2 for excitation, and impresses a uniform static magnetic field to an analyte 5. The gradient magnetic field coil 3 is driven by the drive circuit (drive amplifier) 4 controlled by the system controller 16, and magnetic field intensity impresses the gradient magnetic fields Gx, Gy, and Gz which change linearly to the analyte 5 (for example, human body) on a berth 6 to X and the direction of Y where it intersects perpendicularly in the tomographic layer of the request to observe, and a Z direction perpendicular to these. Under control by the system controller 16, the RF magnetic field where the RF signal from the transmitting section 7 is generated through a duplexer 8 by being impressed by the uniform coil 9 which is a transceiver combination coil is further impressed to an analyte 5.
[0020] Inside the uniform coil 9, it approaches at an analyte 5, and the multi-sir face coil 10 which is a coil for signal detections is arranged. And the magnetic-resonance signal from an analyte 5 is received by the uniform coil 9 and the multi-sir face coil 10. The magnetic-resonance signal received with the uniform coil 9 is led to a receive section 11 through a duplexer 8, and the magnetic-resonance signal received with the multi-sir face coil 10 is directly led to a receive section 11. A duplexer 8 is for using it, changing the uniform coil 9 to transmission and reception, transmits the RF signal from the transmitting section 7 to the uniform coil 9 at the time of transmission, and carries out the work which leads the input signal from the uniform coil 9 to a receive section 11 at the time of reception.
[0021] After the magnetic-resonance signal inputted into the receive section 11 is amplified and detected, it is sent to the data collection section 12 under control by the system controller 16. In the data collection section 12, after collecting the magnetic-resonance signals inputted through the receive section 11 under control of a system controller 16 and carrying out A/D conversion of it, it sends to a computer 13 as data for picture reconstruction.
[0022] A computer 13 is controlled by the console 14 and performs picture reconstruction processing which includes the two-dimensional Fourier transform about the data for picture reconstruction inputted from the data collection section 12. By this picture reconstruction, after obtaining the image data of the number of channels equal to the number of coils of the multi-sir face coil 10, weighting addition of these image data is carried out, and the image data corresponding to the picture of one sheet is compounded. Moreover, a computer 13 also performs control of a system controller 16. The image data got by the computer 13 is supplied to the picture display 15, and a picture is displayed.
[0023] Drawing 2 is the outline cross section showing the composition and arrangement of the uniform coil 9 and the multi-sir face coil 10. The uniform coil 9 impresses a RF magnetic field to the whole field which should image an analyte 5, and it is for carrying out reception detection of the magnetic-resonance signal from an analyte 5 further, and it is arranged so that an analyte 5 may be covered. The uniform coil 9 is a coil which can impress a uniform RF magnetic field to the field which should image an analyte 5, and the quadrature transceiver coil specifically constituted using a saddle type coil, distributed constant type coils, or these coils is used. The multi-sir face coil 10 is formed inside the uniform coil 9, and consists of Sir face coils [two or more (this example six pieces)] 10a-10f arranged by approaching an analyte 5 so that the field of the request which should image an analyte 5 may be surrounded.
[0024] The detail of the receive section 11 in drawing 1 is shown in drawing 3 . The 2nd signal-detection means which the 1st signal-detection means which consists of a preamplifier 21, a detector circuit (DET) 22, and a low pass filter (LPF) corresponding to the uniform coil 9 is established, and consists of Preamplifiers 31a-31f, detector circuits 32a-32f, and low pass filters 33a-33f corresponding to each Sir face coils 10a-10f is established, respectively. That is, the magnetic-resonance signal received, respectively with the uniform coil 9 and the Sir face coils 10a-10f is inputted into the data collection section 12, after it is amplified by the preamplifier 21 and 31a-31f, being further detected by a detector circuit 22 and 32a-32f and an unnecessary component is removed by the low pass filter 23 and 33a-33f.
[0025] In the data collection section 12, the data for picture reconstruction are collected by carrying out sample hold of the detection output of the magnetic-resonance signal inputted from the receive section 11, and digitizing by the A/D converter. This digitized data for picture reconstruction is incorporated by the computer 13 of drawing 1 . Sample hold of all the low pass filter outputs in a receive section 11 is carried out to every [which is decided as a data collection method in the data

collection section 12 in the band of the picture which should be acquired] sampling time (referred to as deltat), there are a method which scans and digitizes each sample hold output between deltat, and a method which carries out sample hold of each low pass filter output one by one, and digitizes it between deltat, and these any may be used.
[0026] The decoupling between both the coils on the relation arranged by the uniform coil 9 and the Sir face coils 10a-10f approaching is needed. The differentiated type coil 40 shown in drawing 4 as the reason of this decoupling, for example, a Sir face coil, is used. This is the same as that of the same axle and the thing which arranges in parallel, connects so that the current of a retrose may flow spatially mutually, and is conventionally used as a differentiated type coil with the squid fluxmeter about two isomorphous ring-like coils 41 and 42, as the principle is shown in drawing 5 . One Sir face coil is constituted by the alignment and the matching circuit which consists of capacitance elements 43-45 connected with this differentiated type coil 40 to the ends. Alignment and a matching circuit are connected to the preamplifier in a receive section 11.
[0027] Thus, RF magnetic field B1 uniform on the space target generated from the uniform coil 9 with the Sir face coil which consists of a constituted differentiated type coil Although it considers as how which induced electromotive force equal to both the coils 41 and 42 produces when it interlinks, since coils 41 and 42 are connected as mentioned above, the electromotive force guided to both the coils 41 and 42 negates each other, and RF current does not flow. Therefore, the decoupling of this Sir face coil will always be carried out to the uniform coil 9 arranged outside. However, it is necessary to generate a spatial sufficiently uniform RF magnetic field in the field to which the Sir face coil which consists of a differentiated type coil as a property of the uniform coil 9 in this case has been arranged.
[0028] S/N at the time of using a differentiated type coil as a Sir face coil is examined by reference:Magn.Reson.Med.3,590-603 (1986). Namely, if S/N of the Sir face coil which consists of this differentiated type coil has the dominant noise component from an analyte, although it is equivalent to S/N in the case of the usual Sir face coil which consists of a 1 turn coil In the situation that the own RF loss of a coil cannot be disregarded, since it is inferior to S/N of the usual Sir face coil, it is necessary to fully examine the distance of a Sir face coil and an analyte, and the interval of two coils 41 and 42 for actual manufacture and arrangement of a coil.
[0029] Next, the decoupling method between the Sir face coils with which it adjoins at the time of using a differentiated type coil as Sir face coils 10a-10f is explained using drawing 6 - drawing 9 . Drawing 6 and drawing 7 show the decoupling method in case the Sir face coil (drawing 10a, 10b) which consists of an adjoining differentiated type coil has been arranged superficially, and drawing 8 and drawing 9 show the decoupling method in case the Sir face coils 10a and 10b have been arranged on a periphery.
[0030] In the case of drawing 6 , decoupling is performed by piling up in a field only the area S decided by area in which a coil surrounds two differentiated type sir face coils 10a and 10b. The same decoupling method about the coil of 1 turn is indicated by for example, the U.S. Pat. No. 4,825,162 specification. In drawing 7 , decoupling is performed by the ability shifting Coils 10a and 10b to shaft orientations (direction perpendicular to the field surrounded with the coil). Drawing 8 transforms the method of drawing 6 . That is, although an area of S " of the lap portion of the coil 42 by the side of inner circumference will differ from area S' of the lap portion of the coil 41 by the side of a periphery when it has arranged on a periphery after incurvating the differential coil type sir face coils 10a and 10b, decoupling becomes possible by arranging Coils 10a and 10b in the specific position which fulfills S" of conditions of >S>S'. Drawing 9 is what transformed drawing 7 , and is the case where the coil 41 and the coil 42 are arranged at the angle theta. In this case, decoupling is realizable by adjusting one differentiated type sir face coil 10b in x of drawing, and the direction of y.
[0031] These decoupling methods are in the state where total of the magnetic field interlinked in the differentiated type coil of another side among the magnetic fields generated when and current flows in a differentiated type coil is 0. [while] Thus, in various arrangement, that decoupling is possible is another feature of a Sir face coil of having used the differentiated type coil.
[0032] Next, the decoupling method between the Sir face coils which do not adjoin is explained. There is little distributor shaft coupling between the Sir face coils which do not adjoin compared

with distributor shaft coupling between the adjoining Sir face coils. Then, it is enough if decoupling is performed paying attention to the influence of distributor shaft coupling being suppressed by making apparent Q low not using the precise decoupling method between the Sir face coils which do not adjoin. What is necessary is just to specifically add a Q damping circuit to each of a differentiated type sir face coil.
[0033] Drawing 10 is the example of a Q damping circuit, and a coil 50 is the frequency fo specific by the inductance L and capacitance element NSU C. Suppose that it is resonating. Parallel resistance Rp shows the impedance of the coil 50 in the resonance state, and is expressed as Rp =2pifo LQ using Q value.
[0034] The inversed input terminal and noninverting input terminal of the amplifier 51 K times the gain of this are connected to the ends of this coil 50, and a feedback resister 52 (it considers as resistance Rf) is further connected between the output terminal of amplifier 51, and an inversed input terminal, and let the output terminal and noninverting input terminal of amplifier 51 be an external end-connection child. The preamplifiers [in / drawing 3 / in fact / in amplifier 51] 31a-31f are used.
[0035] The Q damping circuit which consists of the coil 50, the amplifier 51, and feedback resister 52 of drawing 10 is expressed with the equal circuit shown in drawing 1 . Resistance Rd of drawing 11 Rd =Rf/(K+1)
It is come out and given.
[0036] Therefore, it will be Rp >>Rd if gain K of amplifier 51 is enlarged enough. It becomes, and the impedance of ends will be low and apparent Q will fall by the bird clapper.
[0037] Since distributor shaft coupling between the Sir face coils which do not adjoin depending on the actual arrangement state of a differentiated type sir face coil is small enough, in that case, such a Q damping circuit is unnecessary.
[0038] It is better to use a Q damping circuit for the direction of the Sir face coils 10a-10f, when the decoupling between the uniform coil 9 and each Sir face coils 10a-10f or between adjoining Sir face coils is fully made neither by the coil configuration nor arrangement.
[0039] Next, the procedure of high S/N imaging in this example is explained concretely. The imaging sequence in the case of acquiring a 2-dimensional picture as an example is shown in drawing 12 . This imaging sequence is a pulse sequence for acquiring a 2-dimensional picture with the well-known spin echo which used the 90-degree pulse-180-degree pulse as a RF magnetic field (RF pulse), the gradient magnetic field of the slice direction and Gr show the gradient magnetic field of the lead direction, and, as for Gs, germanium shows the impression timing of the gradient magnetic field of the encoding direction, respectively.
[0040] Magnetic-resonance signals are collected changing the amplitude of the gradient magnetic field germanium for encoding like drawing 12 . Impression of a RF pulse is performed using the uniform coil 9, and reception of a magnetic-resonance signal is performed using the uniform coil 9 and all the Sir face coils 10a-10f (multi-sir face coil 10). The magnetic-resonance signal detected by the receive section 11 through each coils 9, 10a-10f is incorporated by the computer 13 as data for picture reconstruction through the data collection section 12, and picture reconstruction is made by carrying out the two-dimensional Fourier transform in a computer 13. The image data of one channel obtained through the uniform coil 9 by this picture reconstruction and the image data of the multiple channel (this example six channels) obtained through each Sir face coils 10a-10f are obtained. And when weighting addition of the image data of six channels obtained through the Sir face coils 10a-10 and the image data of a total of seven channels which added one channel further obtained through the uniform coil 9 is carried out by the predetermined weight function so that S/N may serve as the maximum, the image data of the picture of one sheet is compounded.
[0041] If it generally thinks that most noises detected with a coil are guidance-noises from an analyte 5, the above-mentioned weight function will be given by [-one number] - [a-three number].
[0042]
[Equation 1]

$$k(R) = -\lambda(R)\,[H_{ij}]^{-1} h(R)$$

但し、H_{ij} ： 行列要素

$$k(R) = \begin{pmatrix} k1(R) \\ \vdots \\ ki(R) \\ \vdots \end{pmatrix}$$

$$h(R) = \begin{pmatrix} h1(R) \\ \vdots \\ hi(R) \\ \vdots \end{pmatrix}$$

[0043]
[Equation 2]

$$\lambda(R) = -\frac{C}{\{[H_{ij}]^{-1} h(R)\}\, h(R)}$$

（C：任意の定数）

[0044]
[Equation 3]

$$H_{ij} = \int_V E_i(r) \cdot E_j(r)\, dv$$

[0045] However, the position vector R indicates the position on a picture (pixel position) to be, the vector which shows the position of the space where r has an analyte, ki The weight function to the image data from which (R) was obtained with the i-th Sir face coil, hi The RF magnetic field distribution whose i-th Sir face coil generates (R), lambda (R) is an amendment correction function and Ei about the sensitivity unevenness of the image data after weighting addition resulting from a RF magnetic field distribution of a Sir face coil. (r) is electric field generated when the unit high frequency current is passed in the i-th Sir face coil. In addition, integration of Hij is performed about the whole analyte.
[0046] Although there is a dielectricity guidance-noise, where [which originates in the noise of the high-frequency resistance resulting from the coil itself, and an analyte as a noise of a coil] an analyte is equipped with a coil, it is thought that the noise from an analyte occupies most. What is necessary is just to take this influence into consideration by changing the diagonal element of a matrix [Hij], when the noise resulting from the coil itself cannot be disregarded. However, in practice, since the diagonal element of [Hij] becomes small compared with a non-diagonal element, and it is easy, you may use the weight function which placed the non-diagonal element of [Hij] with 0.
[0047] In order to determine weight function k (R), it is necessary to ask for each Sir face coils'a [10]-10f RF magnetic field distribution h (R). Hereafter, this is explained. h (r) can be substituted for h (R) in approximation. First, phase correction of the image data obtained through the uniform coil 9 and the Sir face coils 10a-10f, respectively is performed. Here, suppose that the picture as shown in drawing 13 using the uniform coil 9 was acquired. By drawing 13 , a thick line shows the position of the uniform coil 9, and a dashed line shows the position of Sir face coil 10a, respectively.
[0048] The histogram equivalent to the same position of the picture which showed the histogram of the picture on the alternate long and short dash line A of drawing 13 to drawing 14 (a), and was acquired by Sir face coil 10a is shown in drawing 14 (b). It is the signal strength [in / each picture / in drawing 14 (a) and (b), a horizontal axis expresses a position, and / in a vertical axis] ST and SS.

It expresses. According to drawing 14 (b), it turns out that sensitivity has fallen as the picture acquired by Sir face coil 10a separates from the position of Sir face coil 10a. In addition, when S/N of a picture is bad, it is desirable to perform data smoothing, such as the moving average, suitably.
[0049] Next, it asks for the signal strength ratio ha (=SS / ST) of each part grade of an analyte 5. From the histogram of the picture on the alternate long and short dash line A shown in drawing 14 (a) and (b), the result which calculated this signal strength ratio ha is shown in drawing 14 (c). Since image data escapes from the point which does not have a source of a signal from the first, and the point out of which a signal did not come under the influence of the relaxation time etc., interpolation etc. is processed. Since the RF magnetic field distribution which a Sir face coil generates can be developed by the orthogonal function, you may use the method of determining the coefficient of each term of a system of orthogonal functions with the least square method etc. using the image data obtained. It can ask for the RF magnetic field distribution ha covering the whole imaging field of Sir face coil 10a (R) as shows a histogram to drawing 14 (d) by these methods.
[0050] In addition, you may use what took the signal strength ratio ha (=SS / ST) of the part of an analyte 5 like the histogram of drawing 14 (c) simply as RF magnetic field distribution ha (R).
[0051] It is required to ask for a RF magnetic field distribution of the uniform coil 9 beforehand on the other hand, when a RF magnetic field distribution of the uniform coil 9 becomes uneven under the influence of analyte 5 grade in the picture acquired through the uniform coil 9.
[0052] The following methods can also be used although the picture of high S/N of a request field was acquired in the above explanation by carrying out weighting addition of the image data which used as the data for picture reconstruction the raw data of the magnetic-resonance signal acquired from each Sir face coil, and carried out the Fourier transform of this. That is, after the multiple channel with the inverse Fourier transform result of the weight function corresponding to the raw data of the magnetic-resonance signal from each Sir face coil in front of the Fourier transform and these obtained by finding the integral by collapsing collapsing and carrying out addition composition of the integration result, the high S/N picture of a request field can be similarly acquired by carrying out the Fourier transform, respectively.
[0053] The raw data of the magnetic-resonance signal acquired with the i-th Sir face coil about the case of a two-dimensional picture For example, Ifi (Kx, Ky), The weight function of Ii (X, Y) and the i-th picture for the image data after the Fourier transform ki (X, Y), If the inverse Fourier transform of this weight function ki (X, Y) is set to kfi (Kx, Ky) and the high S/N picture finally acquired is set to I (X, Y), a relation as shown in [a-four number] will be realized.
[0054]
[Equation 4]

$$I(X, Y) = \sum_i k_i(X, Y) \cdot I_i(X, Y)$$

$$\iint I(X, Y)\, e^{-i(Kx \cdot X + Ky \cdot Y)}\, dx\, dy$$

$$= \sum_i \iint k_i(X, Y) \cdot I_i(X, Y)\, e^{-i(Kx \cdot X + Ky \cdot Y)}\, dx\, dy$$

$$= \sum_i \iint k_{fi}(Kx', Ky')\, I_{fi}(Kx-Kx', Ky-Ky')\, dKx'\, dKy'$$

[0055] As shown in this [-four number], it turns out that the thing of the raw data Ifi (Kx, Ky) of a magnetic-resonance signal and the inverse Fourier transform kfi (Kx, Ky) of a weight function ki (X, Y) which collapsed and added the integration result about each Sir face coil is equivalent to the

inverse Fourier transform of the picture I (X, Y) finally acquired. Therefore, if the Fourier transform of this is carried out, Picture I (X, Y) can be found.

[0056] Although the decoupling for each Sir face coil 10a-10f was performed by devising the arrangement in the above example, using a differentiated type coil as a Sir face coil, otherwise, the decoupling method is considered variously. For example, you may use a decoupling circuit as shown in drawing 15 - drawing 17 . Drawing 15 (a) is the reactive element Z1 of two kinds of values, and Z2. It is the decoupling circuit which consists of a bridge circuit to depend, and the equal circuit is shown in drawing 15 (b). Terminals a and b and Terminals c and d are connected to the ends of two Sir face coils 10a and 10b which should be carried out decoupling, respectively. Reactive element Z1 and Z2 As it carries out and is shown in drawing 16 , it is the capacitance element C1 and C2. As it uses or is shown in drawing 17 , it is the inductance element L1 and L2. The effect of distributor shaft coupling can be negated by using and adjusting those values.

[0057] Drawing 18 shows the example which applied the decoupling circuit by such bridge circuit to the decoupling between Sir face coil 10a which consists of a 1 turn coil, and 10b, and drawing 19 shows the example applied to the decoupling between Sir face coil 10a which used the differentiated type coil as shown in drawing 4 , and 10b.

[0058] Moreover, the example using the decoupling coils 43-45 which consist of the character type or loop-like coil of 8 is shown in drawing 20 - drawing 22 . The decoupling coil 43 is carrying out distributor shaft coupling of drawing 20 to the Sir face coils 10a and 10b which consist of a 1 turn coil. The magnetic flux which this interlinks to one side of Coils 10a and 10b can be set to 0, and the decoupling of it becomes possible. Drawing 21 and drawing 22 carry out distributor shaft coupling of the decoupling coils 44 and 45 to the Sir face coils 10a and 10b which consist of a differentiated type coil, and decoupling is made similarly.

[0059] The decoupling coils 43 and 44 shown here are butterfly type coils, and itself can realize a decoupling state in the uniform coil 9. However, in order that the decoupling coil 45 may carry out distributor shaft coupling to the uniform coil 9 depending on the sense of the RF magnetic field which the uniform coil 9 generates in the example of drawing 22 , if in charge of application, to separate from an analyte in consideration of arrangement is desired.

[0060] Although the differentiated type coil was used as a Sir face coil in the previous example in order to perform the decoupling for the uniform coil 9, and Sir face coil 10a-10f, when the usual coil is used, you may use a decoupling circuit as shown in decoupling with the uniform coil 9 at drawing 15 - drawing 17 .

[0061] Next, other examples of the high-frequency-coil section which consist of a uniform coil and a Sir face coil are explained. Drawing 23 shows the example which used the differentiated type coil 64 as the birdcage type coil 61 and a Sir face coil as a uniform coil, respectively. The birdcage type coil 61 shown here is called high path type, is parallel to shaft orientations and consists of an inductance element 63 arranged by the circumferencial direction at intervals of predetermined, and a capacitance element 62 which connects between the adjoining inductance element NSU elements 63. That is, the birdcage type coil 61 is constituted by arranging the inductance element 63 and the capstan element 62 in the shape of a ladder.

[0062] two conductors which arranged the differentiated type coil 64 in radial [of the birdcage type coil 61] in the space surrounded with the inductance element 63 which constitutes the birdcage type coil 61, and the capacitance element 62, and have been arranged on the other hand -- from a loop -- becoming -- the conductor of these upper and lower sides -- it connects and consists of capacitance elements 65 so that current may flow a loop to a retrose mutually thus -- if it carries out -- two conductors -- if each magnetic flux interlinked to a loop is equal, induced electromotive force will not be produced to the flux reversal Therefore, the decoupling of the birdcage type coil 61 and the differentiated type coil 64 is possible.

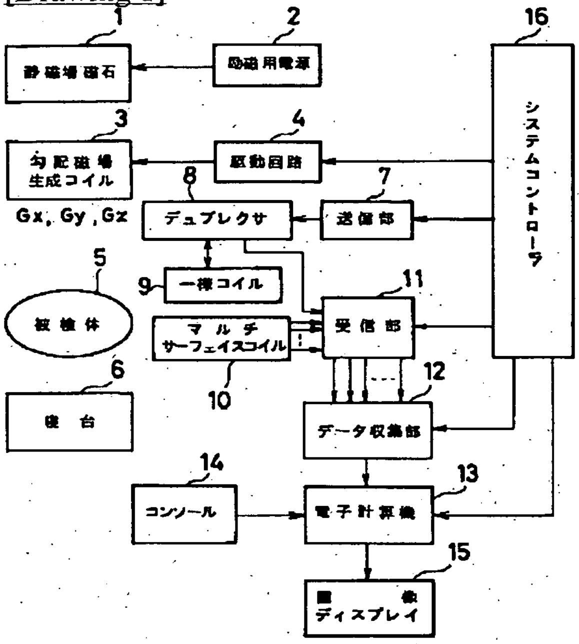
[0063] To take decoupling into consideration is desired also about between the differentiated type coils 64. About the differentiated type coil 64, the magnetic flux which carries out distributor shaft coupling can be intercepted by arranging the conductive board 66 between the coils which adjoin as shown in drawing 24 and drawing 25 . As for this conductive board 66, it is desirable to be arranged in a position which becomes symmetrical [the coil of both sides] on both sides of the conductive board 66, and it is so large that area is large. [of the decoupling effect]

[0064] Next, the example which actually applied the decoupling method explained by drawing 24 and drawing 25 is shown in drawing 26 - drawing 28 . The conductive board 67 is made to serve as the role of the decoupling between the differentiated type coils 64 by constituting an inductance element (it being equivalent to the inductance element 63 of drawing 23) parallel to the shaft orientations in the high path type birdcage type coil 61 from drawing 26 with the conductive board 67.
[0065] Each of drawing 27 and drawing 28 is the examples at the time of using the low-pass type birdcage type coil 71. While the conductive board 72 constitutes an inductance element parallel to shaft orientations from drawing 27 , the capacitance element which consists of an electrode board 73 and a dielectric board 74 in the middle of these conductive boards 72 is inserted, respectively. In this case, it is desirable to bend the edge of the electrode board 73 so that some dielectric boards 74 may be covered so that magnetic flux may not leak even from few portions equivalent to the thickness of the dielectric board 74. Drawing 28 constitutes an inductance element parallel to a shaft from two conductive boards 75 and 76, respectively, and it is made for each point to counter on both sides of the dielectric board 74.
[0066] Drawing 29 shows the example which applied the decoupling circuit explained by drawing 16 to the decoupling between the adjacent differentiated type coils 64 in drawing 23 .
[0067] In addition, when the decoupling between the differentiated type coils which adjoin each other by the above-mentioned method is inadequate, or when distributor shaft coupling between the differentiated type coils which do not adjoin each other (for example, when not much large width of face of the conductive board 66 in drawing 26 cannot be taken) occurs, it is desirable to use together a Q damping circuit as shown in drawing 10 , in order to stop them, and to make apparent Q low.
[0068] Other examples of composition of the high-frequency-coil section which become drawing 30 - drawing 33 from a birdcage type coil and a differentiated type coil are shown. While drawing 30 constitutes an inductance element parallel to shaft orientations from a conductive board 67 in the high path type birdcage type coil 61 Between the center sections of the adjoining conductive board 67 is connected with the conductive board 68 in alignment with the circumferencial direction. Each space surrounded with the inductance element (conductive board 67) and the capacitance element 62 of the birdcage type coil 61 is divided into shaft orientations in two space, and the differentiated type coil 64 is arranged to each of such division space, respectively. In this case, the decoupling between the differentiated type coils 64 which adjoin with the conductive boards 67 and 68 will be performed.
[0069] drawing 31 is in a circle at the center of the capacitance element 78 which is the example which applied the composition same about the low-pass type birdcage type coil 71 as drawing 30 , and has been arranged in the center at shaft orientations -- a conductor -- by letting a board 77 pass Each space surrounded with the inductance element (conductive board 72) and the capacitance element 78 of the birdcage type coil 71 was divided into shaft orientations in two space, and the differentiated type coil 64 is arranged to each division space.
[0070] Drawing 32 is performing magnetic flux which interlinks mutually the decoupling between the differentiated type coils 64 which adjoin each other in shaft orientations by piling up some each coil by making it zero, in order to arrange three or more differentiated type coils 64 to shaft orientations. In addition, even if it uses the decoupling method which was explained by drawing 15 and drawing 16 , three or more differentiated type coils can be arranged to shaft orientations.
[0071] Drawing 33 shows the example which used together the character type coil 69 of the differentiated type coils 64 and 8 as a Sir face coil. The birdcage type coil 61 and decoupling are possible also for any of the character type coil 69 of the differentiated type coils 64 and 8. Since it can arrange so that total of the magnetic flux which interlinks between both the coils 64 and 69 mutually may serve as zero, it becomes unnecessary moreover, to be able to attain easily the decoupling between the Sir face coils which adjoin by arranging both the coils 64 and 69 by turns to a circumferencial direction, as shown in drawing 33 , and to make the inductance element 63 parallel to the shaft orientations of the birdcage type coil 61 into a configuration like the tabular which serves as decoupling.
[0072] Although the birdcage type coil was used as a uniform coil in the above example, since SUROTTEDO tube RIZONETA also has four gaps, it is possible to approach with a uniform coil

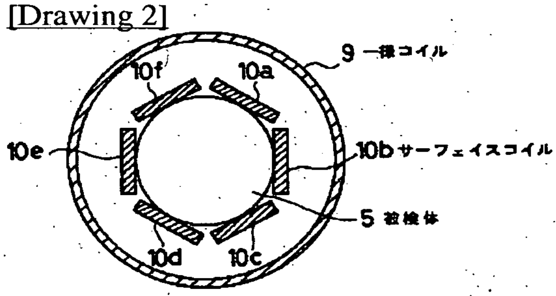
and to arrange the Sir face coil which consists of a differentiated type coil etc. using this gap.
[0073] It is drawing showing arrangement of the high-frequency-coil section using the differentiated type coil as Sir face coils 10a-19h, using a birdcage type coil as a uniform coil 9 as drawing 34 was explained using drawing 23 - drawing 29 , and the sampling coils 10a-10h are arranged in the space surrounded with the inductance element and capacitance element in the birdcage type coil which constitutes the uniform coil 9. If it does in this way, an analyte 5 will be approached, the uniform coil 9 and sampling coils [10a-10h] both can be stationed, and the picture of S/N also with high surface section of an analyte 5 or deep part will be acquired.
[0074]
[Effect of the Invention] When imaging by detecting the magnetic-resonance signal from an analyte through two or more Sir face coils according to this invention, the decoupling between each Sir face coil can be performed effectively.
[0075] Moreover, while arranging two or more Sir face coils miniaturized in the space surrounded with the inductance element and capacitance element which constitute a uniform coil according to this invention By performing the decoupling between both coils and between Sir face coils, and detecting a magnetic-resonance signal using both [these] coils **** near the front face of an analyte can attain high S/N equivalent to the time of using a Sir face coil, and it becomes possible to realize S/N equivalent to the uniform coil which applied the quadrature receiving method at least also in the deep part of an analyte realizing.

DRAWINGS

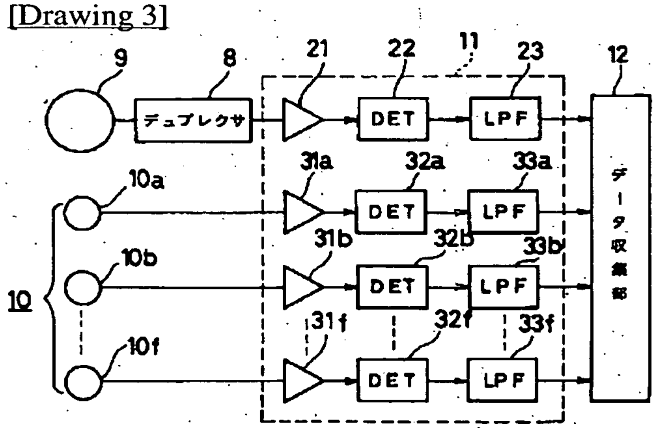
[Drawing 1]



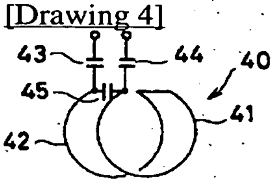
[Drawing 2]



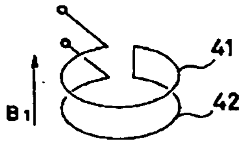
[Drawing 3]



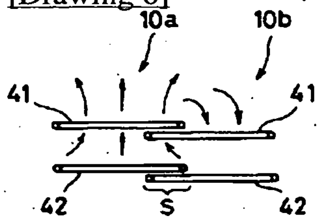
[Drawing 4]



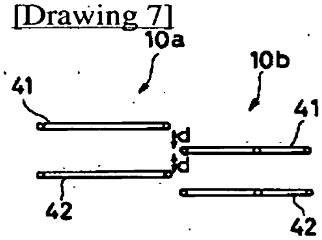
[Drawing 5]



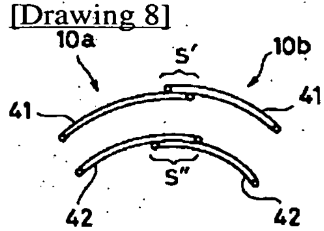
[Drawing 6]



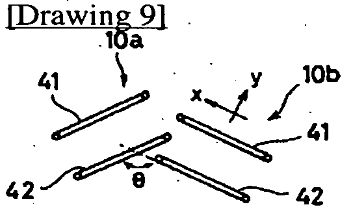
[Drawing 7]



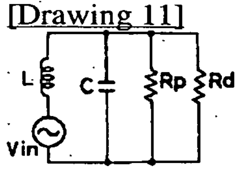
[Drawing 8]



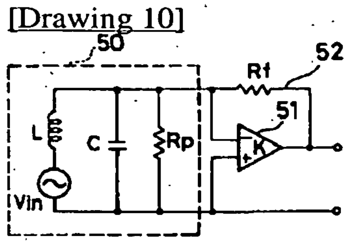
[Drawing 9]



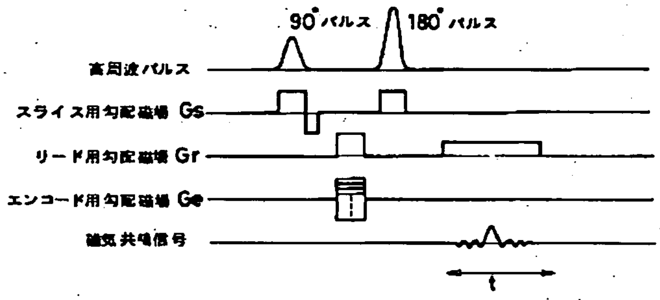
[Drawing 11]



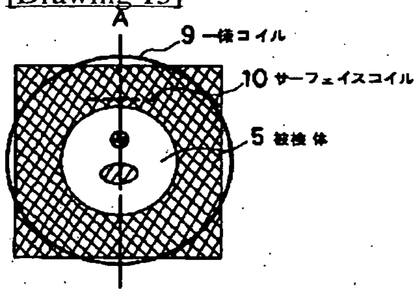
[Drawing 10]



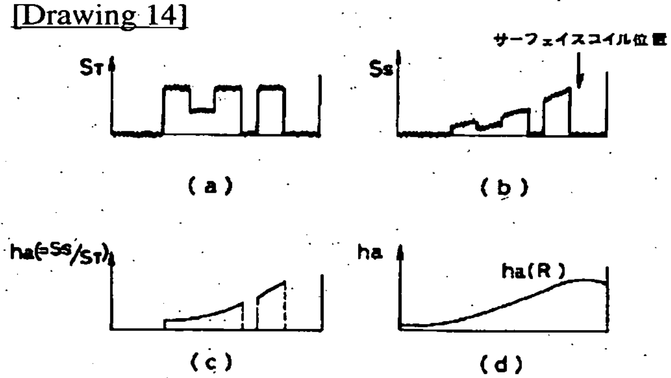
[Drawing 12]



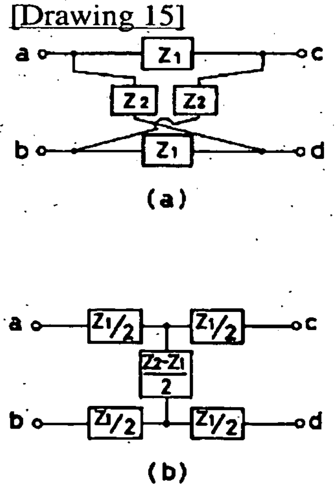
[Drawing 13]



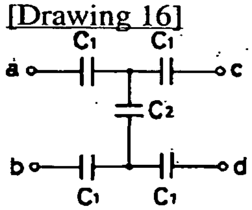
[Drawing 14]



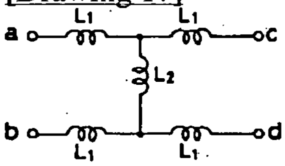
[Drawing 15]



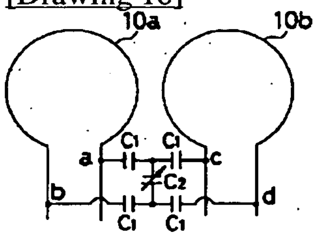
[Drawing 16]



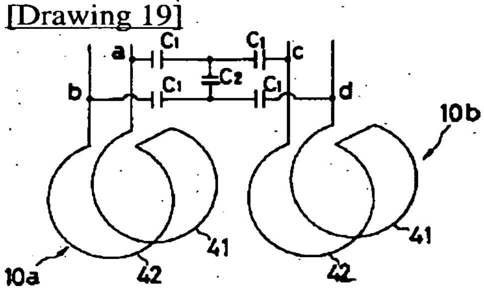
[Drawing 17]



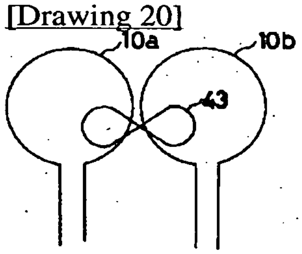
[Drawing 18]



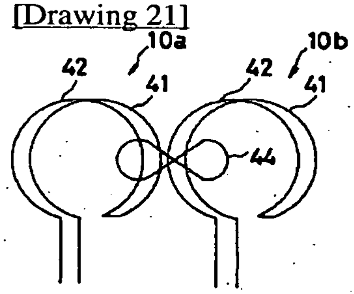
[Drawing 19]



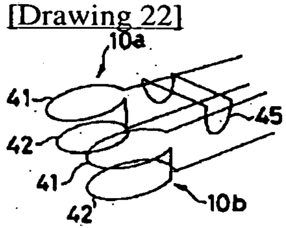
[Drawing 20]



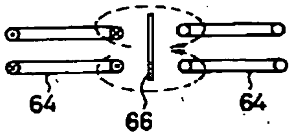
[Drawing 21]



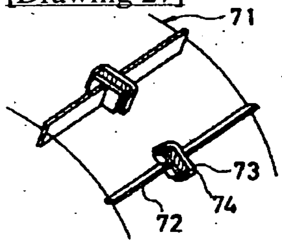
[Drawing 22]



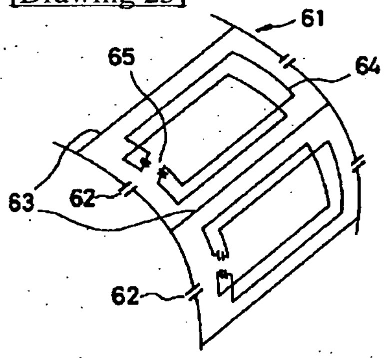
[Drawing 25]



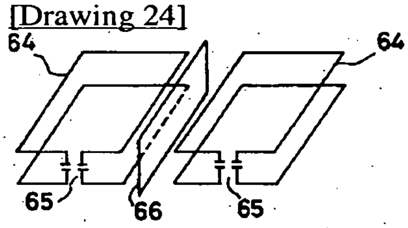
[Drawing 27]



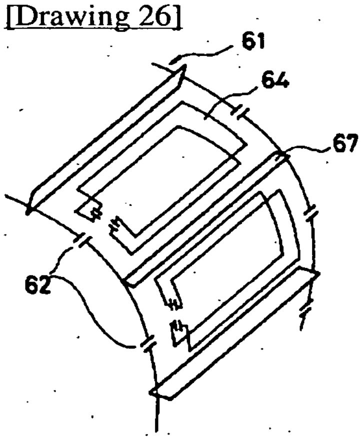
[Drawing 23]



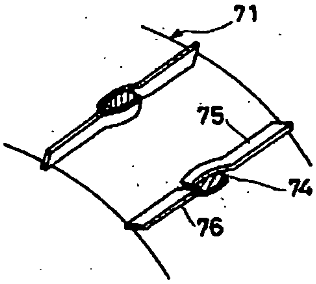
[Drawing 24]



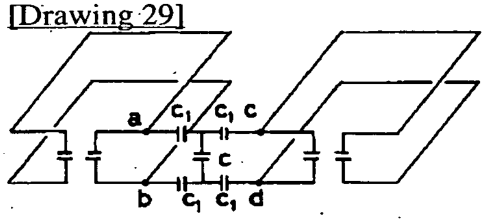
[Drawing 26]



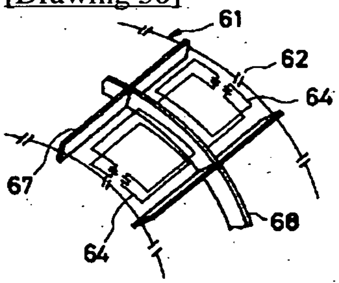
[Drawing 28]



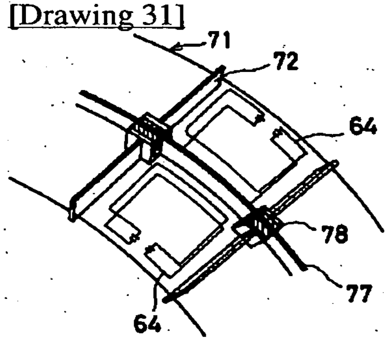
[Drawing 29]



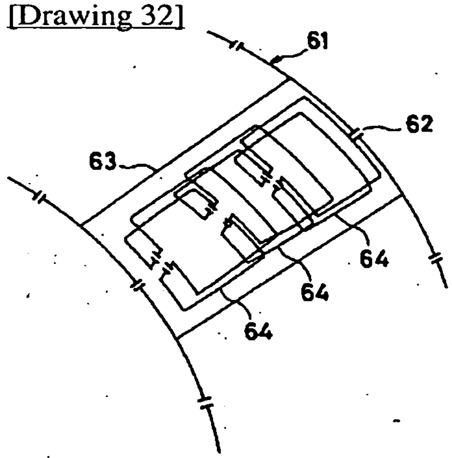
[Drawing 30]



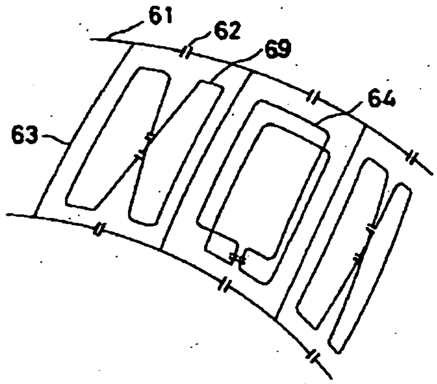
[Drawing 31]



[Drawing 32]



[Drawing 33]



[Drawing 34]